CORRELATED DYNAMICS IN QUANTUM AND OPTICAL FIBERS

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JULY 2013
Final Report

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FA9550-09-1-0094: CORRELATED DYNAMICS IN QUANTUM AND OPTICAL FIBERS (Princeton University)

We use classical light to demonstrate experimentally two phase transitions that are typically associated with low-temperature quantum systems: Bose-Einstein condensation and the Berezinskii-Kosterlitz-Thouless transition. The former is a collapse of random-phase waves into a coherent ground state while the latter is a proliferation of vortices that appears as vortex energy competes with entropy production. In both cases, 2+1D beam experiments are performed using an SBN:60 ($Sr_{0.6}Ba_{0.4}Nb_2O_6$) photorefractive crystal. An ensemble of random-phase input beams is created using a spatial light modulator, each with a Gaussian field profile with adjustable spatial correlation length. Interactions between modes are facilitated by a self-defocusing nonlinearity in the crystal, obtained by applying a voltage across its c-axis. Two CCD cameras then record the output, one for position (x) space and one for momentum (k) space. For the condensation experiment, wave equilibration to a Rayleigh-Jeans spectrum is observed, with an accumulation of energy in the fundamental $k_0 \approx 0$ mode and an algebraic k^{-2} spectrum in the tails. For the BKT experiment, the number of new vortices matches mean-field predictions of a photonic x-y model, as do correlation measurements in the transition region. The results demonstrate condensed matter physics using only light and confirm recent theory about classical wave thermodynamics.